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Torres Strait reefs and carbonate production: a geospatial approach

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TORRES STRAIT REEFS AND CARBONATE PRODUCTION: A GEOSPATIAL APPROACH

A thesis submitted in fulfilment of the requirements
for the award of the degree of

DOCTOR OF PHILOSOPHY

From

THE UNIVERSITY OF WOLLONGONG



By

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ENVIRONMENTAL SCIENCES**

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“The Torres Straits are nearly thirty-four leagues wide; but they are obstructed by an innumerable quantity of islands, islets, breakers, and rocks, that make its navigation almost impracticable; so that Captain Nemo took all needful precautions to cross them. The Nautilus, floating betwixt wind and water, went at a moderate pace. Her screw, like a cetacean's tail, beat the waves slowly.”

- Jules Verne, 20 000 leagues under the sea (p.94, 1963, Airmont:NY)

Certification

I, **Javier León**, declare that this thesis, submitted in fulfilment of the requirements for the award of **Doctor of Philosophy, in the School of Earth and Environmental Sciences, University of Wollongong**, is wholly my own work unless otherwise referenced or acknowledged. The document has not been submitted for qualifications at any other academic institution.

Dedication

This is dedicated to my grandparents from whom I have learnt that the key to enjoying the journey of life resides in keeping things simple, doing what you like most and, of course, having a good company by your side.

Abstract

Coral reefs are particularly valuable marine ecosystems in terms of biodiversity and socio-economic factors. They are also some of the most vulnerable and threatened of global ecosystems, particularly in view of unprecedented anthropogenic-driven disturbances. Understanding coral reef evolution is not straightforward, as these are complex systems where biological, physical and chemical processes continually interact over a range of spatial and temporal scales. The study of coral reef dynamics at geomorphological scales is very suitable for management as it bridges the temporal and spatial gap between long-term geological and short-term ecological processes. Mapping the geomorphology of coral reefs has provided key information to scientists and managers about the distribution and extent of reef landforms giving insights into calcium carbonate (CaCO_3) production and reef growth.

Coral reef coasts present a series of challenges to scientists and managers because they tend to be largely inaccessible, both in that they are isolated and because they are underwater or in intertidal settings where fieldwork is weather and tide dependent. In addition, field surveying rapidly becomes cost-prohibitive as the area of study increases or higher-frequency surveys are needed. Remote sensed data, both from passive and active sensors, together with geospatial analysis techniques, allow addressing the challenges of studying such unique environments at multiple scales and significantly improve the science needed for a sound and efficient management.

Scaling up coral reef CaCO_3 production from community metabolism values to regional estimates has been undertaken using remote sensing and geospatial techniques. This approach, although being of great significance for science and management implications, considerably lags behind ecological models of primary production used in terrestrial applications. Furthermore, previous regional studies are geographically constrained and have been based mostly on generalized published metabolic values and coarse mapping.

The research which is the focus of this thesis aims to bridge the gap between detailed and regional geomorphological studies on coral reefs by scaling up CaCO_3 production across the Torres Strait region. In order to do so, two reefs in central Torres Strait

were selected, namely Sue (Warraber) and Bet (Burrar) reef platforms and detailed investigations about morphology and carbonate production were undertaken. Insights from the local case studies were further used to extrapolate carbonate production estimates across the region based on a reliable geomorphological classification dataset.

The case study reefs were selected as they represent different stages of geomorphological evolution. Sue platform is an emergent reef extending for approximately 12.6 km², while Bet, immediately to the north of Sue, is a larger reef extending for 27 km² with a mostly submerged lagoon and very shallow intertidal reef flat. A combination of data collection methods, including multibeam echosounding, RTK-GPS survey and optical remote-sensing derived bathymetry were used to analyse the complex terrain of both reefs. Previous ecological surveys combined with geomorphological mapping were used to scale up CaCO₃ production for the complete platforms, including the productive forereef. The CaCO₃ production for Sue was estimated to be 19,432 t CaCO₃ year⁻¹, averaging a production rate of 1.81 CaCO₃ m⁻² yr⁻¹. The estimate for Bet platform added to an average 88,167 t CaCO₃ year⁻¹, yielding a rate of 3.1 kg CaCO₃ m⁻² yr⁻¹.

Despite being a northern extension of the Great Barrier Reef (GBR), the geomorphology of coral reefs in Torres Strait remains unexamined at a detailed level. Innovative classification and spatial analysis techniques were used to accurately map the intra-reef geomorphology of reefs, which was used as a basis to extrapolate CaCO₃ production and derive a regional carbonate production for Torres Strait. A maximum total of 9.6 million tonnes CaCO₃ yr⁻¹ were estimated for the 2,500 km² analysed region, averaging a value of 4.1 kg CaCO₃ m⁻² yr⁻¹, almost twice the 2.4 kg CaCO₃ m⁻² yr⁻¹ productivity rate previously estimated for the GBR.

Overall, the geospatial framework adopted in this study effectively complemented the regional scaling up of CaCO₃ production for Torres Strait. Results improve and advance our knowledge of coral reef dynamics at geomorphological scales, which are very relevant for management and adaptation, particularly in regards to the future prospect of corals in a rapid changing climate context.

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